

Traditional dried starter culture (*Medombae*) for rice liquor production in Cambodia

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Abstract

Medomdae is a Cambodian traditional dried starter culture used to produce alcoholic beverages and other fermented products. Its main ingredients are rice flour, different types of plants, herbs and spices and microorganisms from previous batches of *medombae*. This study aimed to describe the traditional method of *medombae* processing; enumerate microorganisms present in *medombae*; and evaluate the physicochemical and sensory properties of rice liquor using traditional *medombae*. Interview and documentation of local *medombae* and rice liquor production were conducted. Enumeration of microorganisms in traditional *medombae* was done using standard pour plating technique. Rice liquor from the three types of starter cultures were subjected to physicochemical and sensory analyses. *Medombae* samples contained 10^5 to 10^7 CFU g^{-1} molds; 10^7 to 10^8 CFU g^{-1} yeasts; and < 5 CFU g^{-1} acid-producing bacteria with starter culture from Vietnam obtained the highest counts. Rice liquor using traditional *medombae* had lower alcohol content, purified alcohol, yield and acceptability compared to rice liquor using Vietnamese starter cultures. This indicated that the method of Cambodian starter culture production still needs the right microorganisms and needs knowledge on the interactions and process by-products for optimum activity to produce desired product components.

Keywords

Medombae

Mold and yeast

Solid state fermentation

Liquid state fermentation

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Introduction

Medomdae or *Mesra* (rice cake starter culture or fermented rice cake) is a traditional starter culture used to produce alcoholic or fermented foods in Cambodia, such as *srasor* (Khmer traditional rice liquor), *tapae* (fermented waxy rice), *srapeang* (fermented rice wine), *seang* (fermented soybean), *teukkhmes* (vinegar). These traditional starter cultures have various names in different countries, e.g. *loog-pang* in Thailand, *marcha* or *murcha* in India, *ragi* in Indonesia, *bubod* in the Philippines, Chinese yeast in Taiwan, *nuruk* in Korea (Tsuyoshi *et al.*, 2005), *banh men* in Vietnam, *koji* in Japan and *ragi tapai* in Malaysia (Limtong *et al.*, 2005).

The process of *medombae* production had been learned by producers from their parents, relatives and non-relatives. Some local producers have stopped making the starter culture because *medombae* from Vietnam and China are cheaper and widely available in the market. Also, rice liquor producers

have commented that *medombae* made in Cambodia produces low liquor yield though better liquor taste. Some consumers even complained that rice wine or liquor produced from starter culture made in Vietnam or China result in excessive hang over and stomach problems. Thus, identification of issues and improvement of the technique or method of producing instant starter culture should be investigated.

Yamamoto and Matsumoto (2011) reported that homemade starters, including plant materials, have been used for the production of fermented rice (called *tapae* in Khmer), rice liquor and palm liquor. Kozaki (2007) discussed one case of starter production among the Krung in northeastern Cambodia, but information on such a case is very limited. Kato *et al.*, (2006) reported only about the microorganisms used in dried starters in Cambodia. However, very little is known about the starter culture processing method, and the traditional methods of production are now in danger of dying out because of the availability of inexpensive starters imported from Vietnam and

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China. The study aimed to evaluate the traditional method of *medombae* processing; enumerate the microorganisms present in *medombae*; and determine the physicochemical and sensory properties of rice liquor using traditional *medombae* as compared to the imported starter cultures (2) from Vietnam.

Materials and Methods

Research Site

The research was conducted in Kampong Cham, Cambodia which is located on the eastern side of Cambodia bordered by Kratie province to the northeast, Vietnam to the East, Prey Veng to the South, Kampong Chhnang province to the west and Kampong Thom province to the northwest. Kampong Cham is 123 kilometres northeast of Phnom Penh and can be reached by either boat or land transport. It takes about 2 hours by land or 2.5 hours by boat from Phnom Penh to the city of Kampong Cham. Traditional starter culture is produced in the whole country but starter culture from Kampong Cham is more popular despite its lower liquor yield.

Documentation and evaluation of the Cambodia's traditional method of processing starter culture

Current and former producers, and vendors of starter culture were interviewed. Three (3) producers, two (2) former producers and one (1) vendor of starter culture were selected for representative and sources of starter in the study. Observation and documentation of traditional method of processing starter culture and rice liquor production were conducted to identify the issues and possible solving the current problems faced by the local producers.

Enumeration of microorganisms in starter culture

The enumeration of microorganisms from starter culture was performed. Ten grams (10 g) of sample was added to 90 ml of 0.85% NaCl solution. Series of dilution were carried out and 1 ml of appropriate dilution was plated using the standard pour plating technique. Malt yeast extract Agar (MYA) medium containing 0.2% sodium propionate for yeasts; glucose yeast extract peptone (GYP) medium containing calcium carbonate for bacteria (10% glucose, 1.0% yeast extract, 2.0% calcium carbonate, 1.5% agar); and potato dextrose agar (PDA) medium containing 10% tartaric acid per 100 ml for molds were used. The petri dishes were incubated upside down at 30°C for 2-3 day for yeasts, 24-30 hours for bacteria and 4 or 5 days for molds were counted and reported as colony forming units per mL (cfu g⁻¹).

Comparison of physicochemical properties of rice liquor utilizing selected starter cultures

Experimental design

Completely Randomized Design (CRD) was used to design the experiment in which three treatments and three replications were generated. The starter culture utilization was *Medombae* Kampong Cham, *Medombae* Vietnam, and powdered *Phuong Trang* (Vietnam), respectively.

Rice liquor processing

The Angko Srouv Krohorm rice used was bought from Takeo province. *Medombae* Vietnam and *Phuong Trang* starter cultures were purchased from the local market but imported from Vietnam and *medombae Kg Cham* was obtained from Kampong Cham. Clean water was utilized for washing milled rice, cooking of rice and fermentation of rice for liquor production. The total fermentation time was ninety six hours.

Rice preparation

Ordinary white rice (10 Kg) was weighed and washed 2 to 3 times with water to remove rice bran and husks or until the water became clear.

Steaming of rice

Water was poured into the bottom of the steamer and rice was spread uniformly on the tray above it and then covered. Rice was cooked by first boiling for 30 minutes and stirred while water was added; boiling of rice was continued for another 30 minutes, then stirred again and water was added; boiling of rice was again done for 30 minutes until the rice is well done. In the first stirring and spraying of water, the water added was equal to the amount of rice but in the second stiring, the amount of water sprayed was only half of the water used in the first addition. Then, the cooked steamed rice was taken out of the steamer and transferred to a plastic mat for cooling.

Inoculation of rice with starter culture

The steamed rice was spread thinly on the plastic mat and cooled at room temperature from 35°C to 38°C. The starter culture (2.5% based on milled rice) was mixed evenly with the steamed rice and then placed in earthenware jars.

Solid state fermentation

Steamed rice inoculated with starter culture was placed in earthenware jar for fermentation. The fermentation temperature and conditions were monitored daily for 48 hours at ambient room

condition.

Liquid state fermentation

After 48-hour fermentation, water was poured into the jars at the rate of 1 part milled rice to 3 parts water (1:3) (For examples, milled rice 1 Kg and water added 3Kg/L. The temperature was checked 24 hours. Thus, the period of fermentation took a total of 96 hours for rice liquor processing. After completed fermentation, the pH, TTS, TSS and Alc. was measured.

Distillation of fermented rice for liquor production

The liquid part of the fermented rice was poured at the bottom of the distillation pan while the solid fermented rice was placed on the surface of a distilling pan. The burned fermented rice was also placed in the distillation pan to allow the liquor to drip. Dripping was stopped when the alcohol concentration reached 10%.

Physicochemical analysis of fermenting rice and liquor

The temperature of the fermenting rice was taken every 24 hours until the end of fermentation using a laboratory thermometer (glass, alcohol filled, -0°C to 10°C, graduation 1°C with a card board/plastic cover and cotton on both ends). The pH during liquid fermentation was also measured. On the other hand, the alcohol content and total titratable acidity were determined at the end of fermentation period. At the final stage of rice liquor production, the total amount of liquor, alcohol content (%), purified alcohol and percentage yield were determined.

pH

A pH meter was calibrated using pH buffers 4 and 7. Enough amount of sample was placed in a beaker with volume 100-ml and the pH was recorded.

Total soluble solids (TSS, oBrix)

A drop of the sample was placed on the sample holder of a hand refractometer and the value, where sharp boundary line of light and dark areas meets, was recorded.

Total titratable acidity (TTA).

Ten mL (10 mL) of each sample was pipetted and transferred into an Erlenmeyer flask, and then 2-3 drops of phenolphthalein were added. This was titrated using 0.1 N NaOH until a faint pink color appeared. TTA was calculated using:

$$TTA = V_{NaOH} \times F$$

$$\text{where : } F = \frac{0.1N \text{ NaOH}}{\text{Standardized NaOH}}$$

Alcohol (%)

One hundred mL (100 mL) of rice liquor was placed into a 100-mL capacity graduated cylinder. This was refrigerated for 15 minutes until the temperature of the liquor reached 15°C. The alcohol meter was allowed to float freely on the sample and then the alcohol content was recorded. The reading was expressed as % alcohol (v/v) (Alan, 2011).

The purified alcohol was calculated using the formula:

$$\text{Purified alcohol (L)} = \frac{\text{Volume of Alcohol (L)} \times \text{Alcohol percentage (\%)}}{100}$$

Yield. It is defined as the quantity of final product per kilogram of raw material used. Yield was calculated using the formula:

$$\text{Yield (L/Kg)} = \frac{\text{Purified alcohol (L)}}{\text{Weight of raw rice (Kg)}}$$

Sensory evaluation of rice liquor

The standard general procedure of sensory evaluation will be followed as described by Tand and Mabesa (1998) to evaluate whether the liquor product. About 15 ml of the prepared rice liquor for the different treatments will be dispensed in a clean, "shot" glass coded with 3-digit random numbers and placed on serving plates. Panel of judges consisting of 15 Bachelor of Science in faculty of Agro-Industry major students and staff who had classroom training and always involved in sensory evaluation evaluated the sensory attributes of the prepared rice liquor sensory test. Sensory properties such as clarity, aroma, flavor, bitterness and general acceptability of rice liquor were determined using Quality Scoring test with 7-point hedonic scale. (Range of Scores: Clarity: 1 = Very turbid; 7 = Very clear, Aroma: 1 = Very atypical rice liquor; 7 = Very typical rice liquor, Bitterness: 1 = Not bitter; 7 = Very bitter, Flavor: 1 = Very weak alcohol; 7 = Very strong alcohol, General Acceptability: 1 = Very unacceptable; 7 = Very acceptable). A score of 7 was the highest possible value from the panel testing, and a score of 4 was the cut-off point.

Statistical analysis

Data was analyzed using Analysis of Variance (ANOVA). Samples found to be significantly different were further subjected to Duncan's New

Table 1. Amounts of plants, herbs and spices used for starter culture production

1	Rice flour		<i>Oryza sativa</i> L.	500
Plants used				
2	ឈើឆាម Chheuem/licorice		<i>Alcizia myriophylla</i> (<i>Glycyrrhiza glabra</i> Linn)	1.5
3	ផ្លែក្រូច Chhkesreng		<i>Cananga latifolia</i>	1.5
4	ឈើត្រីដូង Chheupleung		<i>Diospyros nitida</i> Merr.	1.5
5	ទេពវិញ Tepirou		<i>Cinnamomum polyadelphum</i> (Lour.) Kosterm	1.5
6	ក្រវាញ Kravanh		<i>Amomum krervanh</i>	1.5
7	ស្នាច Smach		<i>Melaleuca cajuputi</i> / <i>Melaleuca leucadendron</i> L.	1.5
Spices and herb				
8	រំដេង Rumdeng		<i>Alpinia galangal</i>	1
9	ម្រូស Chili		<i>Capsicum annuum</i> , <i>C. frutescens</i>	1
10	ម្រេច Black pepper		<i>Piper nigrum</i>	1
11	ឆ្កែ Ginger		<i>Zingiber officinale</i>	1
12	ឆ្កឹម Garlic		<i>Allium sativum</i>	1
13	<i>Medombae</i>		Starter culture	

Source: Personal communication (2013)

Multiple Range Test (DNMRT) to find the difference among samples.

Results and Discussion

Documentation of traditional method of processing *Medombae*

Milled rice preparation. Ordinary or glutinous milled rice (especially broken rice which is cheaper than whole milled rice) or rice bran was the main raw material for producing *medombae* in Cambodia. The amount of rice bran mixed with milled rice used depends on the preference of the local producers. The milled rice was soaked overnight, drained and then pounded with locally made wooden pestle and mortar to produce wet rice powder.

Plants used in starter preparation. Plants added in the pounded rice were *Alcizia myriophylla* (*Glycyrrhiza glabra* Linn), *Cananga latifolia*, *Diospyros nitida* Merr., *Cinnamomum polyadelphum* (Lour.) Kosterm, *Amomum krervanh*, *Melaleuca cajuputi*/*Melaleuca leucadendron* L. (Table 1). These plant materials were cultivated locally in Kampong. These are boiled for 30 minutes in a pan which was prepared a day prior to preparing new batch of starter

culture. According to *medombae* producers, the plants are commonly used as traditional medicines, which can also enhance the odor and taste of rice liquor. These plants also help to improve blood flow and reduce muscle pain.

Herbs and spices. Herbs and spices are used as ingredients for making *medombae*, namely; *Alpinia galangal*, *Capsicum annuum*, *C. frutescens*, *Piper nigrum*, *Zingiber officinale*, and *Allium sativum*. These were pound together at varying amounts. Fresh ginger, garlic and spices such as chili, pepper and cloves were added during the preparation of dried starter. In most cases, the initial inoculum comes from the local floral nectar which contains wild yeasts and other microorganism. The spices may contain also other microorganisms and may inhibit growth of undesirable microorganisms (Sie, 1962; Soedersono, 1972). According to Frazier (1967), the essential oils found in spices have some inhibitory properties against some microorganisms. Although most spices are not very bacteriostatic, they may exhibit a specific effect in combination with other materials in foods. These herbs and spices are usually used as food ingredients in several Cambodian dishes and known to help enhance the odor and taste of rice

Table 2. Viable microbial cell count (CFU g⁻¹) and moisture content of *medombae*

Dried Starter Culture	Viable Cell Count (CFU g ⁻¹)			Moisture content (%)
	Mold	Yeast	Acid-producing Bacteria	
* <i>Medombae</i> KgCham	7 x 10 ⁵	9 x 10 ⁷	<5	12.2-13.5
** <i>Medombae</i> VN	1.3 x 10 ⁷	1.2 x 10 ⁸	-	10.4-11.5
***Powder Phuong Trang	1.4 x 10 ⁶	1.8 x 10 ⁷	-	9.8-11.2

**Medombae* from Kampong Cham, Cambodia

***Medombae* Vietnam

***Powder starter culture from Vietnam

liquor.

Preparation of milled rice powder, plants extract, and herbs and spices mixture. The milled rice powder, plant extracts, and herbs and spices were mixed together. One percent of old *medombae* was inoculated and mixed well. Water was added based on the amount needed for daily processing and on the amount of mixture for molding to achieve the desired consistency. The mixture was then molded by hand to a round shape. The newly inoculated *medombae* was placed on top of rice hull layers and covered with cloth for 3 days incubation at room temperature and then dried under the sun for around three days or until dried. The dried *medombae* was placed in plastic bags and then stored at room temperature. During incubation, drying and storage, the temperature and conditions for the growth of microorganisms were not being monitored by the *medombae* producers. Based on the interview with the producers, hot or summer season is the best time for making starter culture. Temperature is a very important environmental factor in the growth of microorganisms. It influences the formation of metabolic by-products, enzyme activities, and the morphological and chemical composition of the microbial cells. Every organism has a minimum, optimum and maximum temperature for growth. Nowadays, knowledge of the process of *medombae* production is limited only to some families because the recipes were being kept secret and the technique is just passed on from one generation to another.

Medombae is similar with other dried amylolytic starter cultures used for the production of fermented beverages and alcoholic drinks in other Southeast Asian countries. It is known as *marcha* in the Himalayan region of India, Nepal, Bhutan, and Tibet in China (Tamang, 2010); *manais* in Nepal prepared from wheat (Tamang, 2010); *ragi* in Indonesia in the form of dried, flat cakes (Tanimura et al., 1977); *nurukis* in Korea (Park et al., 1977); *loogpang* in Thailand (Vachanavinich et al., 1994); *banh menis* in Vietnam (Dung, 2004); and *chiu-yueh* or *peh-yueh*, an ethnic Chinese amylolytic starter for *lao-chao*, a fermented rice product (Wang and Hesseltine, 1970). However, it is different from *koji*, a mold culture

being prepared from steamed/cooked cereal in Japan (Lotong, 1985).

The *Alcizia myriophylla* (*Glycyrrhiza glabra* Linn), *Cananga latifolia*, *Diospyros nitida* Merr., *Cinnamomum polyadelphum* (Lour.) Kosterm, *Amomum krervanh*, *Melaleuca cajuputi*/ *Melaleuca leucadendron* L. were included in the preparation of starter culture in Cambodia because local people believed that rice wine or liquor made with starter culture containing these plants would taste sweet. Moreover, the spices and herbs used for starter culture processing are known for their antimicrobial properties; and besides these are hot, and spicy, which are the preferred taste or flavor of Cambodians.

Enumeration of microorganisms in *Medombae*

Medombae collected from Cambodia varied in shape, size and viable microbial contents. The shape is usually round and flat with size of 38 mm diameter x 35 mm thickness (Table 1). Mold content ranged from 10⁵ to 10⁷ cfu g⁻¹, yeast count from 10⁷ to 10⁸ cfu g⁻¹; while acid-producing bacteria was present only in *medombae* Kg Cham with < 5 cfu g⁻¹ test (Table 2). The absence or very low count of acid-producing bacteria might be attributed to the higher moisture content requirement of bacteria compared to molds and yeast. In particular, the lactic acid bacteria are sensitive to low water activity environment. Sanchez (1986) reported that the population of molds in *bubod* was 10³-10⁵ cfu g⁻¹ and yeasts 10⁷-10⁸ cfu g⁻¹ which is in agreement with the results of this study. In general, the mold and yeast populations of the *medombae* samples are relatively high. These, however, may contain both desirable and undesirable microorganisms brought about by the lack of quality control during starter culture production. Based on the morphological characteristics, dominant molds have similar growth appearance on agar medium regardless of the source of starter culture. It is important to note that there are common additives used by the producer in making *medombae* which is claimed to act as preservative and antimicrobial agents and perhaps limit the growth of other microorganisms.

Moreover, moisture content of the starter culture samples were analyzed and found that the lowest

Table 3. Physicochemical properties of fermenting rice mash

Parameter	* <i>Medombae</i> KgCham	** <i>Medombae</i> VN	*** <i>Me Phuong</i> Trang
pH after 72 hrs fermentation	4.0 ^a	4.0 ^a	3.3 ^b
pH after 96 hrs fermentation	4.0 ^a	4.0 ^a	3.5 ^b
TTA after 96 hrs fermentation (ml) ^{ns}	4	4	4.1
TSS after 96 hrs fermentation (°Brix)	5.3 ^b	5.5 ^{ab}	6.0 ^a
Alc. after 96 hrs fermentation (%)	5.6 ^b	7.1 ^a	7.0 ^a

Means within row with the same superscripts are not significantly different at $P \leq 0.05$

TTA – total titratable acidity

TSS – total soluble solids

**Medombae* from Kampong Cham, Cambodia

***Medombae* from Vietnam

***Powder starter culture from Vietnam

value was obtained from the powdered sample (9.8-11.2%). The highest moisture content was presented from *medombae* KgCham (12.2-13.5%) and the only starter culture where acid-forming bacteria were present. The values of moisture content in all samples were relatively low and may be considered stable against contamination by other microorganisms when properly packaged and stored under refrigeration temperature.

Physicochemical properties of rice liquor using different starter culture

Rice liquor was produced using ordinary rice (10 kg). The amount of steamed rice and water added were 22.67 kg and 30 L, respectively. Cooking of rice took around four hours to complete and the distillation process was around three hours using the local distillation set up for rice liquor production.

The temperature of the inoculated cooked rice was monitored during solid state fermentation. It was observed that the temperature of fermenting rice started to rise on the 24th hour and continuously increased on the 48th hour of fermentation to as high as 38-39°C regardless of starter culture used. This increased in temperature indicated released of ATP during active growth of the molds and other special type of yeast like *Saccharomyces* spp. During fermentation, various biochemical changes occurred in the main mash. First, starch changed to the alpha form by steaming and was saccharified by saccharification amylases to glucose and other sugars such as maltose, isomaltose, and panose. Saccharification amylases are relatively stable and continue to act in the main mash throughout fermentation. Second, glucose was fermented by yeast to form ethanol and carbon dioxide. Lactic, succinic, and other organic acids are produced during fermentation. In general, the first two acids (what are those), being nearly equal in concentration with malic acid, accounted for approximately 90%

of the total organic acids (Iwata *et al.*, 2003). The solid state fermentation is a critical stage during rice wine processing because it is where molds convert rice starch into fermentable sugar by the process known as saccharification. If the temperature is very high (>40°C), the starter culture may be inactivated and the thermophilic spore-forming bacteria may dominate the microbial population causing poor quality product; while if the temperature is very low (<28°C), the starter culture will have slow activities resulting in longer time or slow fermentation. According to Chim *et al.* (2012) reported that the fermentation temperature affected the yeast activity, causing a decrease in the productivity of pure ethanol and ethanol percentages. The fermented rice in ambient temperature with plastic bag-covered pots and in room temperature were suitable temperatures for rice liquor production. Temperatures between 30 to 38°C were the best rice fermentation conditions.

During liquid state fermentation (LSF), water was added. The α -amylase enzymes produced by the starter culture liquefy the mash resulting in less viscous mixture with slightly acidic, sweet and alcoholic taste. The fermentable sugar was converted to ethanol by the yeast. Saccharification and fermentation proceeded simultaneously in the unfiltered, dense, mushy mash. This particular set up led to a very high population of yeast cells in the mash and high ethanol contents in the rice liquor. In wine or beer making, the fermentation is a one-step process: the conversion of glucose to ethanol. In sake production, the starch in steamed rice is being broken down to glucose and the glucose is converted to ethanol. Scientists differentiate the two processes in making wine and sake and are termed as single fermentation for the former and double fermentation the latter (Iwata *et al.*, 2003).

The pH after 72 and 96 hours fermentation, total acidity, total soluble solids and alcohol content of fermenting rice mash are presented in Table 3. The pH

Table 4. Physicochemical properties of rice liquor using different starter cultures

Items	* <i>Medombae</i> <i>KgCham</i>	** <i>Medombae</i> VN	*** <i>Me Phuong</i> <i>Trang</i>
pH	4.2 ^c	4.6 ^a	4.4 ^b
TSS (°Brix)	12.3 ^b	13.7 ^a	11.3 ^c
TSS	0.36 ^a	0.33 ^b	0.35 ^a
Total liquor (L)	8.4 ^b	10.1 ^a	8.95 ^{ab}
Alcohol (%)	26.3 ^b	35.33 ^a	33.67 ^a
Purified alcohol (L)	2.2 ^b	3.55 ^a	3.02 ^a
Yield (L/Kg)	0.22 ^b	0.36 ^a	0.30 ^a

Mean within row with the same superscripts are not significantly different at $P \leq 0.05$

**Medombae* from Kampong Cham, Cambodia

***Medombae* from Vietnam

***Powder starter culture from Vietnam

Table 5. Mean sensory scores of different attributes of rice liquor produced from different starter cultures

Starter Culture	Clarity ^{ns}	Aroma	Bitterness	Flavor	Generally Acceptability
* <i>Medombae</i> <i>KgCham</i>	6.0	4.8 ^{ab}	4.7 ^{ab}	5.1 ^b	5.1 ^{ab}
** <i>Medombae</i> VN	6.1	5.7 ^a	5.4 ^a	6.0 ^a	5.9 ^a
*** <i>Me Phuong</i> <i>Trang</i>	5.8	4.2 ^c	4.1 ^c	4.5 ^b	4.4 ^c

Mean values in the same column with the same superscripts are not significantly different at $P \leq 0.05$.

**Medombae* from Kampong Cham, Cambodia

***Medombae* from Vietnam

***Powder starter culture from Vietnam

Range of Scores:

Clarity: 1 = Very turbid; 7 = Very clear

Aroma: 1 = Very atypical rice liquor; 7 = Very typical rice liquor

Bitterness: 1 = Not bitter; 7 = Very bitter

Flavor: 1 = Very weak alcohol; 7 = Very strong alcohol

General Acceptability: 1 = Very unacceptable; 7 = Very acceptable

was significantly lower in samples inoculated with *me phuong trang* (pH 3.3-3.5) after 72 hrs and 96 hrs of fermentation compared to pH 4.0 for both fermenting rice samples inoculated with both *medombae* VN and *medombae* *KgCham*. However, the total acidity was not significantly different in all types of starter culture at the end the fermentation. Imported starters (*Medombae* VN and *Me phuong Trang*) produced significantly higher alcohol content compared to *medombae* *KgCham*. In general, the alcohol content of all the samples is still considered low ranging from 5.6-7.1%. With this, it is evident that the Cambodian starter production technique still needs considerable improvement in terms of incorporation of suitable microorganisms for efficient conversion of starch to simple sugars and yeast capable of producing high alcohol for rice liquor processing.

Percentage yield

Significant differences was observed on the amount of rice liquor, alcohol content, purified alcohol and yield using Kampong Cham and Vietnamese starter cultures (Table 4). The rice liquor produced using Vietnamese starter culture showed significantly higher yield compared to rice liquor produced using Kampong Cham starter culture. Likewise, the rice

liquor produced using Kampong Cham starter culture obtained lower amount of rice liquor, and alcohol content.

Around 70% of the local rice liquor producers are using imported starter from Vietnam and only 19.5% use local starter (Chim et al., 2011). According to the starter culture vendors in the market, rice liquor from starters produced locally commonly produce low alcohol content and yield, however, they still prefer it over the imported starters because it gives better taste product. Moreover, customers prefer rice liquor produced using the Cambodian starter because they are used to the flavor and aroma of the locally-produced rice liquor. Cambodian starter most probably contributed by the added plants, herbs and spices during *medombae* production. The liquor manufacturers, on the other hand, prefer the imported starter cultures from Vietnam because of higher yield compared to the local ones. This gives the local liquor producers more profit in their business. It is concluded therefore that improvement or modification of the traditionally produced Cambodian starter, like inclusion of useful microorganisms during production, should be properly addressed to be competitive both in the local and international markets.

Sensory evaluation

Sensory attributes (clarity, aroma, bitterness, flavor and general acceptability) of rice liquors produced using different starter cultures are presented in Table 5. No significant differences were observed in clarity among samples. In terms of aroma, bitterness, flavor and general acceptability, liquor produced using *medombae* VN from Vietnam obtained the high mean scores as compared to liquor produced using *medombae* KgCham from Cambodia. The values revealed that *medombae* VN had moderately typical rice liquor aroma, moderately bitter, strong alcoholic flavor and moderately acceptable. This signified that *Medombae* Vietnamese starter culture could produce more acceptable rice liquor compared to the Cambodian starter.

Conclusion

Medombae is an amylolytic starter culture from Cambodia in the form of dry and flat cakes used for processing alcoholic beverages and other fermented products. Milled non-waxy rice or millet or other starch containing crops are used as the main substrate for traditional *medombae* production. Plant extract, herbs and spices were also included during starter preparation. Old *medombae* is used as source of inoculum for the new batch of starter preparation. The procedure of *medombae* production was learned by the local producers from their parents, relatives and neighbors.

Mold content ranged from 10^5 to 10^7 cfu g^{-1} , yeast count from 10^7 to 10^8 cfu g^{-1} . However, acid-producing bacteria were present only in *medombae* KgCham of < 5 cfu g^{-1} test. The starter culture from Vietnam obtained the highest counts of viable microorganisms. Moreover, moisture content of the samples fall within the range of 9.8-13.5 % signifying that stability during storage. Imported starters (*Medombae* VN and *Me phuong Trang*) produced significantly higher alcohol content compared to *medombae* KgCham. In general, the alcohol content of all the samples is still considered low ranging from 5.6-7.1%. In addition, The yield and sensory attributes showed that starter culture from Vietnam could produce more acceptable rice liquor compared to the Cambodian starter. With this, it is evident that the Cambodian starter production still needs the right microorganisms and needs knowledge on the interactions and process by-products for optimum activity to produce desired product components.

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